

FIRE SAFETY OBJECTIVES

- To provide for the safety of occupants in buildings, and to make provision for their evacuation or refuge during a fire or other emergency.
- To provide for the safety of fire fighters fighting a fire.
- To provide for the safety of adjoining property and to prevent the spread of fire.
- To provide for the preservation of the property itself.

**Let's discuss a typical
fire alarm design.**

Where do we begin?

**Is a fire alarm system
required?**

Fire Alarm System Design and Layout Considerations

IBC [2000] 907 FIRE ALARM AND DETECTION SYSTEMS

- **907.1.1 Construction documents.** Construction documents for fire alarm systems shall be submitted for review and approval prior to system installation. Construction documents shall include, but not be limited to, all of the following:
 1. A floor plan.
 2. Locations of alarm-initiating and notification appliances.
 3. Alarm control and trouble signaling equipment.
 4. Annunciation.
 5. Power connection.
 - 6. Battery calculations.**
 7. Conductor type and sizes.
 - 8. Voltage drop calculations.**
 9. Manufacturers, model numbers and listing information for equipment, devices and materials.
 10. Details of ceiling height and construction.
 - 11. The interface of fire safety control functions.**

Layout Aids & Tools

- Codes & Standards
- Handbooks
- Reference Material
- Pocket Guides
- Templates
- Calculators
- Fire Modeling Software
- SPL Meter (dBA)
- Intelligibility Analyzer
- V-O-M
- Design Specification
- UL Fire Protection Equipment Directory

Determine the Occupancy Classification

- **Life Safety Code - Chapter 4**
- **Model Building Code - Chapter 3**

Fire Alarm System Components

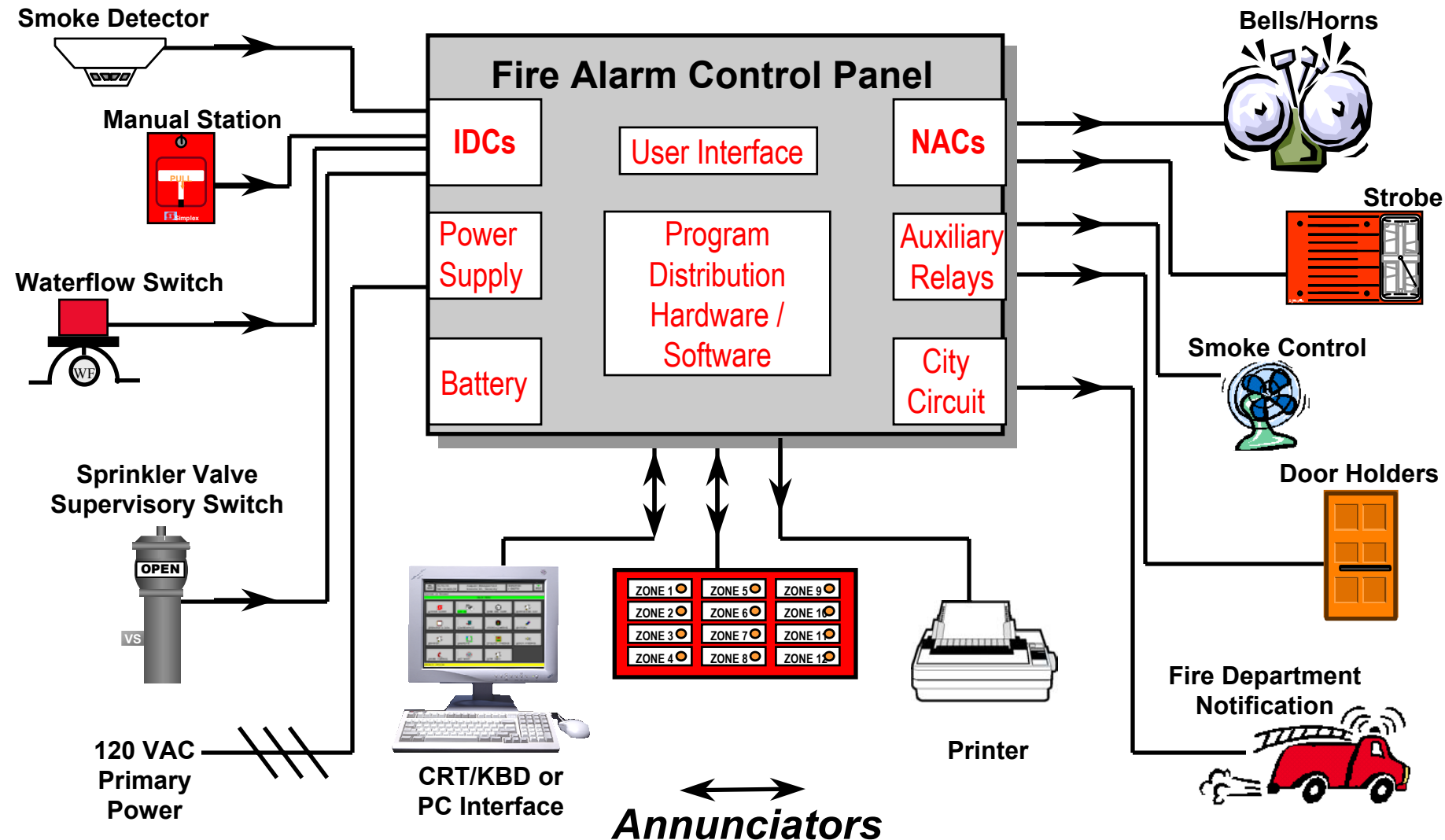
Fire Alarm System Components

- Fire Alarm Control Unit (*FACU*)
- Initiating Devices
- Notification Appliances
- Emergency Controls (*Fire Safety Functions*)
- Supplementary Equipment

Inputs →
Initiating Devices

Logic/Control

Outputs →
Notification Appliances and Emergency Controls



NFPA 72 [2002]

4.4.1.5 Secondary Power Supply

■ 4.4.1.5.1 Secondary power for protected premises

- (1) ...dedicated storage battery
- (2) ...dedicated branch circuit of a generator with dedicated storage battery for 4 hours

NFPA 72 [2002]

4.4.1.5 Secondary Power Supply

■ 4.4.1.5.3* Capacity

24 hours standby – 5 minutes alarm (evacuate)

24 hours standby – 15 minutes alarm (Emergency Voice / Alarm Communication Systems)

24 hours standby – Supervising Stations

Note: NFPA 72 [1999] calls for 60 hours standby for an Auxiliary or Remote Station system

Battery Calculations

Recommendation

Use manufacturers' battery charts that depict the aging and discharge degradation curves for the batteries

Fire alarm system requirements are found in:

- **NFPA 101, Life Safety Code**
- **Model Building Codes**

Many jurisdictions make local modifications to national codes

Visible Notification Appliances

- **Used to alert the hearing impaired**
- **Used in high ambient noise level areas**
- **May be used to indicate the location of the origin of the alarm**

**Be sure to use the
applicable Code
enforced by the
jurisdiction.**

Review the physical properties of the building

- **building height?**
- **number of floors?**
- **area of each floor?**
- **smoke compartments?**
- **sprinklered?**

What fire alarm equipment is required in this occupancy?

Where are fire alarm devices required?

Determine if there is a special use or occupancy

- **Model Building Code - Chapter 4**
- **Life Safety Code - Chapter 11**
 - **High-Rise Building**
 - **Underground Structure**
 - **Atriums**

Once the fire alarm requirements are determined, install per the applicable standards:

EXAMPLES

- **NFPA 72, *National Fire Alarm Code***
- **NFPA 90A, *Installation of HVAC Systems***
- **ANSI/ASME A17.1, *Safety Code for Elevators and Escalators***
- **ANSI/CABO A117.1, *Accessible and Useable Buildings and Facilities***



Do not test with magnets or push to test buttons. They do not ensure smoke entry into the sensing chamber.



The clarity or intelligibility of the voice message must be checked when speakers are being used for voice communications.

Are breakers identified?



CHARE INTERNATIONAL AIRPORT SHUTTLE
DEPARTS THE HOTEL
EVERY HOUR ON THE HOUR
FROM 6:30AM UNTIL 10:30PM

WOODFIELD MALL SCHEDULE

THURSDAY -

DEPARTS	POKES
10:30AM	200PM
1:30PM	400PM
4:30PM	640PM
7:30PM	800PM

FRIDAY -

DEPARTS	POKES
10:30AM	200PM
1:30PM	300PM
4:30PM	400PM
7:30PM	500PM
10:30PM	700PM
3:30PM	9:15 PM

SATURDAY -

DEPARTS	POKES
10:30AM	200PM
1:30PM	300PM
4:30PM	400PM
7:30PM	500PM
10:30PM	700PM

SUNDAY -

DEPARTS	POKES
10:30AM	200PM
1:30PM	300PM
4:30PM	400PM
7:30PM	500PM
10:30PM	700PM

AREA SHUTTLE SERVICE IS AVAILABLE
BASED UPON AVAILABILITY TO
THE ARLINGTON PARK RACETRACK & LOCAL RESTAURANTS

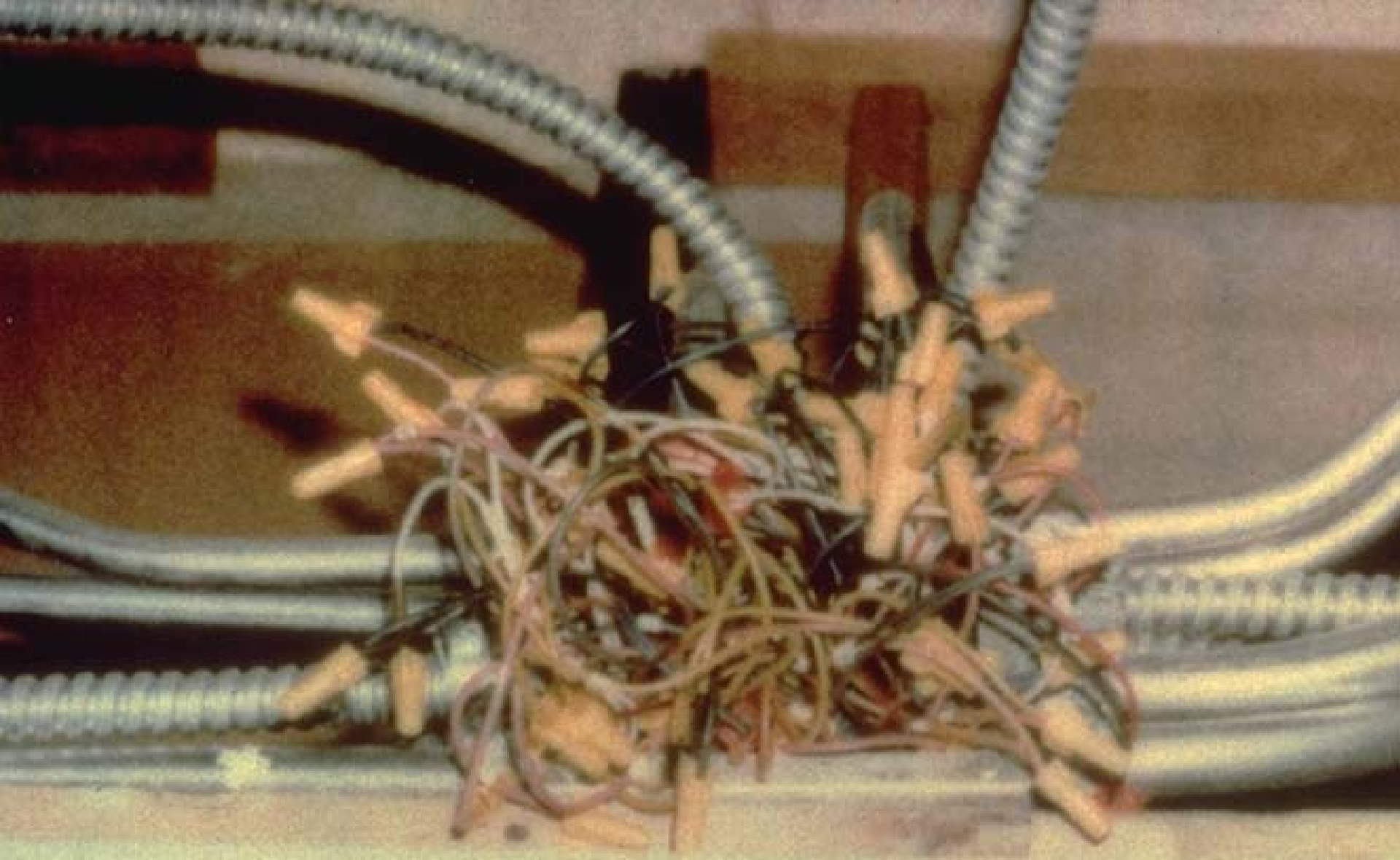


Workmanlike Manner

What does that mean?

760.6 Mechanical Execution of Work.

- Fire alarm circuits shall be installed in a neat and workmanlike manner. Cables and conductors installed exposed on the surface of ceiling and sidewalls shall be supported by structural components of the building in such a manner that the cable or conductors will not be damaged by normal building use. Such cables shall be attached to structural components by straps, staples, hangers, or similar fittings designed and installed so as not to damage the cable. The installation shall also conform with 300.4(D).



Are junction boxes overloaded?

Are fire alarm relays installed properly?





Are sprinkler control valves supervised or locked?



Are tamper switches installed correctly?



NFPA 72 [2002] - Initiating Devices

5.7 Smoke-Sensing Fire Detectors.

- ⌘ 5.7.1.11 Detectors shall not be installed until after the construction cleanup of all trades is complete and final.

Exception: Where required by the authority having jurisdiction for protection during construction. Detectors that have been installed during construction and found to have a sensitivity outside the listed and marked sensitivity range shall be cleaned or replaced in accordance with Chapter 10 at completion of construction.



NFPA 72 [2002] - Fundamentals

4.4.5* Protection of Fire Alarm Control Unit(s). In areas that are not continuously occupied, automatic smoke detection shall be provided at the location of each fire alarm control unit(s) to provide notification of fire at that location.

Exception: Where ambient conditions prohibit installation of automatic smoke detection, automatic heat detection shall be permitted.

NFPA 72 [2002] – Elevator Recall

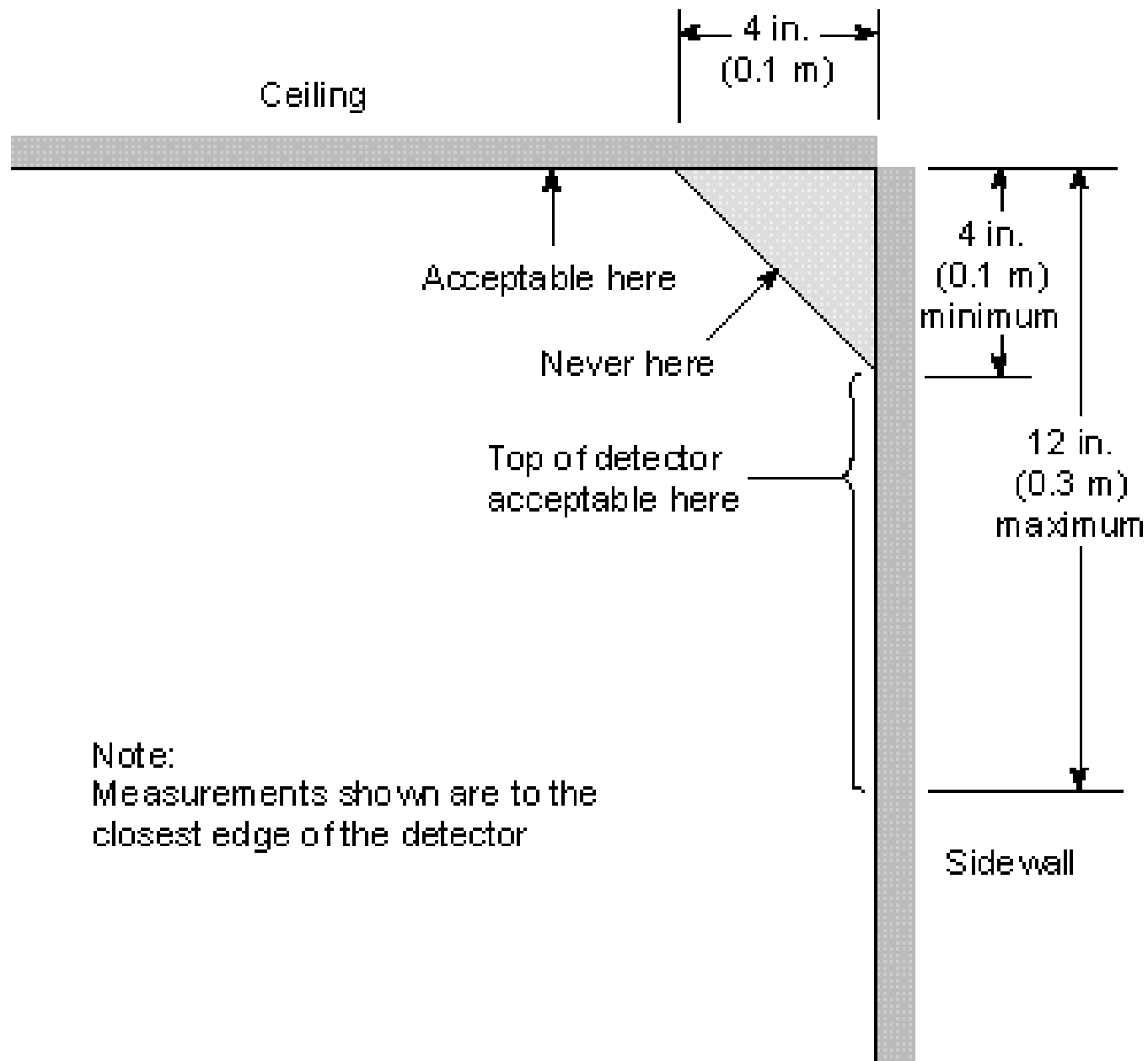
6.15.3.5* A lobby smoke detector shall be located on the ceiling within 21 ft of the centerline of each elevator door within the elevator bank under control of the detector.

Exception: For lobby ceiling configurations exceeding 15 ft in height or that are other than flat and smooth, detector locations shall be determined in accordance with Chapter 5.

NFPA 72 [2002] - Initiating Devices

5.7 Smoke-Sensing Fire Detectors.

- ⌘ 5.7.3.2.1* Spot-type smoke detectors shall be located on the ceiling not less than 4 in. from a sidewall to the near edge or, if on a sidewall, between 4 in. and 12 in. down from the ceiling to the top of the detector.



Note:
Measurements shown are to the
closest edge of the detector



Initiating Devices

Smoke Detector Mounting

- ⌘ Use a smoke detector that is listed for “releasing service” as well as area protection and mount it on the wall above the elevator door(s) and about 10 ft. AFF (*above finished floor*)

The purpose of this detector is to initiate elevator recall should the lobby area become unsafe as a result of smoke or fire.

NFPA 72 [2002] - Initiating Devices

3.3.37 Compatibility Listed. A specific listing process that applies only to two-wire devices, such as smoke detectors, that are designed to operate with certain control equipment. (SIG-FUN)

4.4.2 Compatibility. All fire detection devices that receive their power from the initiating device circuit or signaling line circuit of a fire alarm control unit shall be listed for use with the control unit.

Initiating Devices

Situation #1

- A 30 year old system ... 2 bad smoke detectors ... need to be replaced ... those detectors are no longer made.

The new replacements are not listed with the old panel.

System cannot receive a certificate

Initiating Devices

2-Wire Smoke Detector Compatibility Issue

- Check for compatibility listing in the UL Fire Protection Equipment Directory
- Check with manufacturer of new equipment ... is the equipment electrically compatible?
- Check with UL for determination as to how to resolve any conflict

***Design & Layout
Considerations***

for

Notification Appliance Circuits

Voltage Drop Calculation

- 4.5.1 Approval and Acceptance
 - 4.5.1.1* The authority having jurisdiction shall be notified prior to installation or alteration of equipment or wiring.
 - ...complete information regarding the system or system alterations, including specifications, shop drawings, battery calculations, and notification appliance circuit voltage drop calculations shall be submitted for approval.”

Voltage Drop - What's the Big Deal?

- Crucial for proper design and operation of Notification Appliance Circuits (NACs)
- Under alarm condition, there must be sufficient voltage at each notification appliance ...

..... otherwise, the appliance (*horn, speaker, or strobe*) may not work properly to provide sufficient notification for people to know to evacuate.

Factors Impacting or Impacted by Voltage Drop

- Starting voltage from the control unit
- Voltage required at the appliance
- Length of circuit
- Circuit load (current draw of all appliances)
- Size of wiring conductors
- Calculation method

Background - Standards

- Applicable UL Standards
 - ⌘ UL 864 — Control units for signaling systems
 - ⌘ UL 464 — Audible signal appliances
 - ⌘ UL 1971 — Signaling devices for the hearing impaired

Control Panel Voltage



- UL 864 — Control Units for Signaling Systems
 - ⌘ Proper operation at 85% and 110% of input voltage
 - ⌘ **102 VAC - 132 VAC**
 - ⌘ Proper operation at UL's end battery voltage
 - ⌘ **20.4 VDC**

Starting voltage for calculation:

20.4 VDC

UL Nameplate vs Operating Range

- UL 464 — Audible Signaling Appliances, and
- UL 1971 — Signaling Devices for the Hearing Impaired
 - UL Test Appliance to 80% and 110% of “**Nameplate**”
 - ⌘ Simplex Appliance Nameplate = 22V to 29V



Appliance Label

Nameplate Voltage Range

I.D. NO.: 4903 - 9426

DATE CODE: 3999

VOLTS DC: 22 - 29

AMPS: STROBE 134mA



LISTED

AUDIBLE SIGNAL APPLIANCE FOR FIRE ALARM
SERVICE, ALSO SUITABLE AS SIGNALING
APPLIANCE FOR THE HEARING IMPAIRED.

INSTL INSTR

574 - 917 REV A



SIMPLEX TIME RECORDER CO.
GARDNER, MA 01441 USA

526 - 676 D

UL Nameplate vs Operating Range

- UL 464 — Audible signaling appliances, and
- UL 1971 — Signaling devices for the hearing impaired
 - UL Test Appliance to 80% and 110% of **“Nameplate”**
 - ⌘ Simplex Appliance Nameplate = 22V to 29V
 - **“Operating Range”** = 80% to 110% of Nameplate
 - ⌘ Simplex Appliance Operating Range = 17.6V - 31.9V

Minimum **“Operating”** Voltage

17.6 VDC



Lump Sum Method *(Recommended)*

- Recommended practice
 - ⌘ Calculate voltage drop with entire load at end of circuit
 - ⌘ Use current at lowest “nameplate” voltage
- Provides margin of safety for unknowns
 - ⌘ Actual installed wire length
 - ⌘ Actual distance between appliances
 - ⌘ Temperature (ambient)
 - ⌘ Voltage at the control unit

Audibility

- The total sound pressure level produced ... **shall not exceed 120 dBA** anywhere in the occupiable area.
(7.4.1.2)
- **Public Mode**
 - ⌘ 15 dB above ambient or 5 dB above an ambient source having a duration of more than 60 seconds (7.4.2.1)
- **Private Mode**
 - ⌘ 10 dB above ambient or 5 dB above an ambient source having a duration of more than 60 seconds (7.4.3.1)

Audibility

■ Sleeping Areas

- ⌘ 15 dB above ambient or 5 dB above an ambient source having a duration of more than 60 seconds or 75 dBA, whichever is greater, measured at pillow level. (7.4.4)

Audibility – Background Noise

Table A.7.4.2 Average Ambient Sound Level According to Location

<u>Location</u>	<u>Average Ambient Sound Level (dBA)</u>
Business occupancies	55
Educational occupancies	45
Industrial occupancies	80
Institutional occupancies	50
Mercantile occupancies	40
Mechanical rooms	85
Places of assembly	55
Residential occupancies	35
Storage occupancies	30
Thoroughfares, high density urban	70
Thoroughfares, rural and suburban	40
Tower occupancies	35
Underground structures and windowless buildings	40
Vehicles and vessels	50

NFPA 72 [2002] – Definitions

3.3.122.1 Private Operating Mode. Audible or visible signaling only to those persons directly concerned with the implementation and direction of emergency action initiation and procedure in the area protected by the fire alarm system. (SIG-NAS)

3.3.122.2 Public Operating Mode. Audible or visible signaling to occupants or inhabitants of the area protected by the fire alarm system. (SIG-NAS)

NFPA 72 [2002] – Chapter 7

■ Audibility Requirements

7.4.2* Public Mode Audible Requirements.

7.4.2.1* To ensure that audible public mode signals are clearly heard, unless otherwise permitted by 7.4.2.2 through 7.4.2.5, they shall have a sound level **at least 15 dB above the average ambient sound level** or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft. above the floor in the occupiable area, using the A-weighted scale (dBA).

NFPA 72 [2002] – Chapter 7

■ Audibility Requirements

7.4.3 Private Mode Audible Requirements.

7.4.3.1 Audible notification appliances intended for operation in the private mode shall have a sound level of **not less than 45 dBA at 10 ft.** or more than 120 dBA at the minimum hearing distance from the audible appliance.

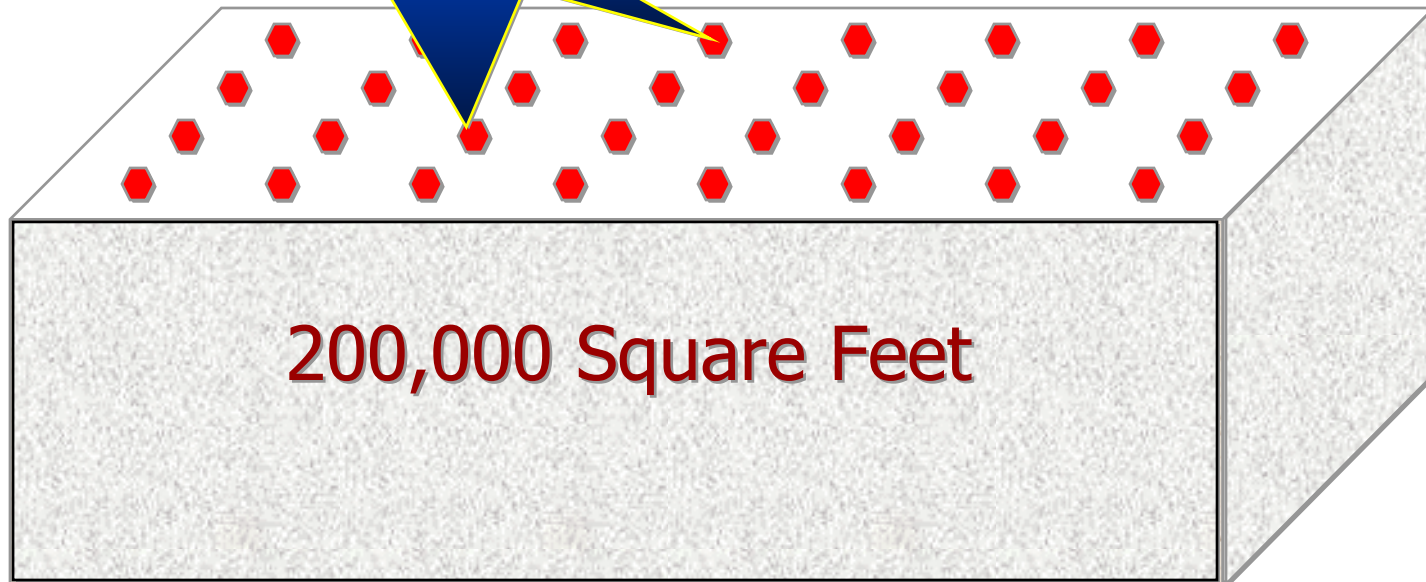
7.4.3.2* To ensure that audible private mode signals are clearly heard, they shall have a sound level **at least 10 dB above the average ambient sound level** or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft. above the floor in the occupiable area, using the A-weighted scale (dBA).

Fire Alarm Audibility

- **Historically - Louder is Better**
- **Use fewer, but louder appliances**
- **Does the job for less money!**

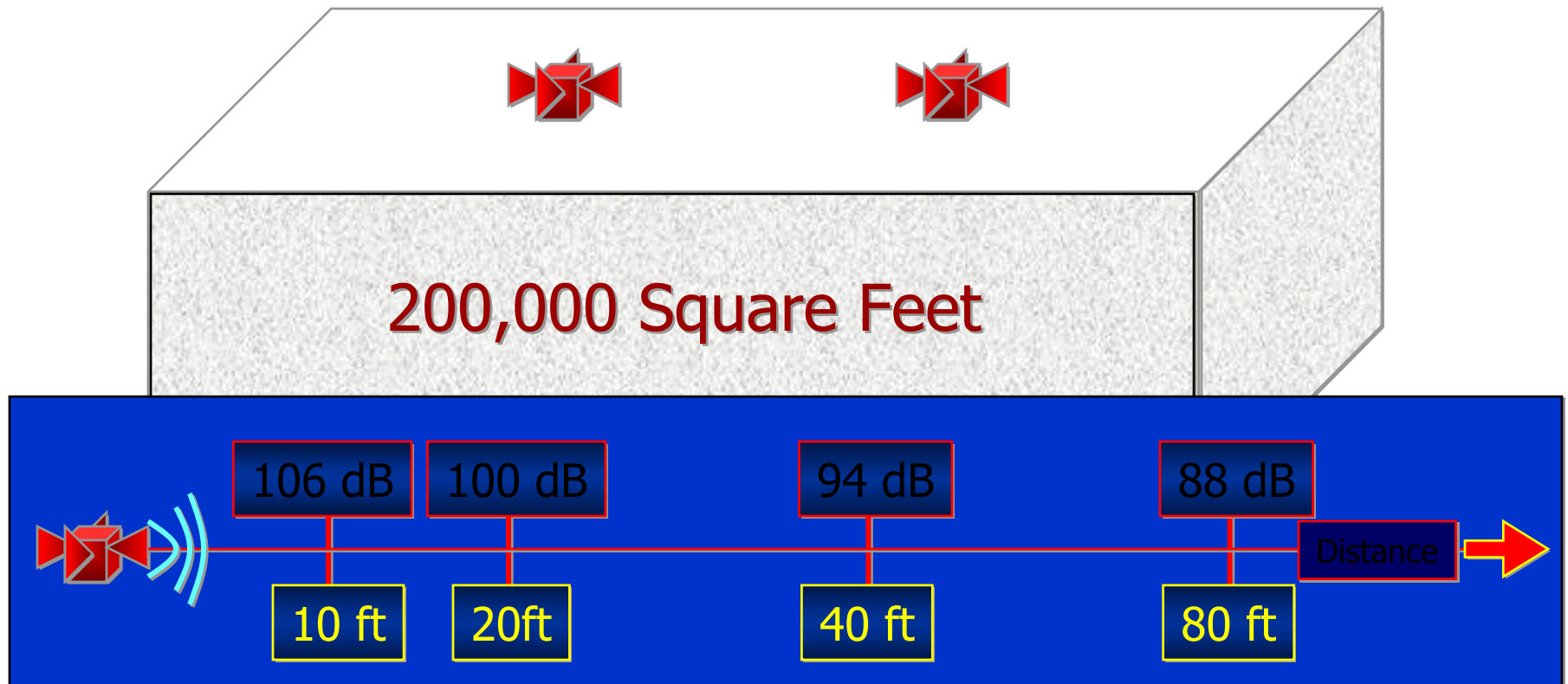
Fire Alarm Audibility

32 devices @ 92 dB Output
mounted on ceiling



Fire Alarm Audibility

8 devices @ 106-110 dB
Output mounted on ceiling



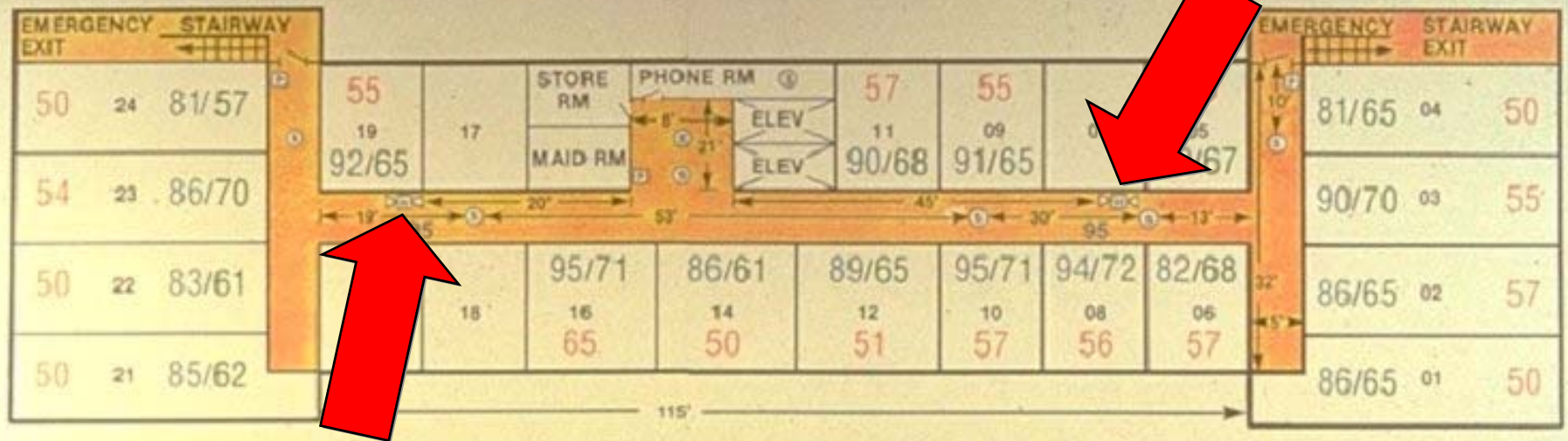
Fire Alarm Audibility

■ Attenuation of Sound

	Average Loss	Typical Range
Open Door	8 dBA	4-12 dBA
Closed Door	17 dBA	10-24 dBA
Sealed Door	28 dBA	22-34 dBA
Stud Wall	39 dBA	32-42 dBA

Fire Alarm Audibility

■ Attenuation of Sound



AUDIBILITY

- - AT PILLOW
- - OUTSIDE DOOR
- - INSIDE DOOR
- - CORRIDOR
- - AT 10' (FEET)

- STATION
- SMOKE
- HORN A/V
- ELEV SMOKE ONLY

Alarm Signal Audibility
Typical Hotel

Voice Notification

- Voice systems provide an effective means of emergency notification, because voice messages provide more information than a tone or bell
 - ⌘ Effective in causing a desired reaction from occupants
 - ⌘ Reduce panic during emergencies
 - ⌘ Accommodates multiple threats (*fire, security, bio, weather*)

Voice Intelligibility

- NFPA 72 National Fire Alarm Code requires that conventional evacuation tones be **audible** (*15 dB louder than the background noise level*).
- Voice intelligibility is not the same as audibility
- A voice message can be **audible** (*loud enough*), but still not be **intelligible** (*understandable*).



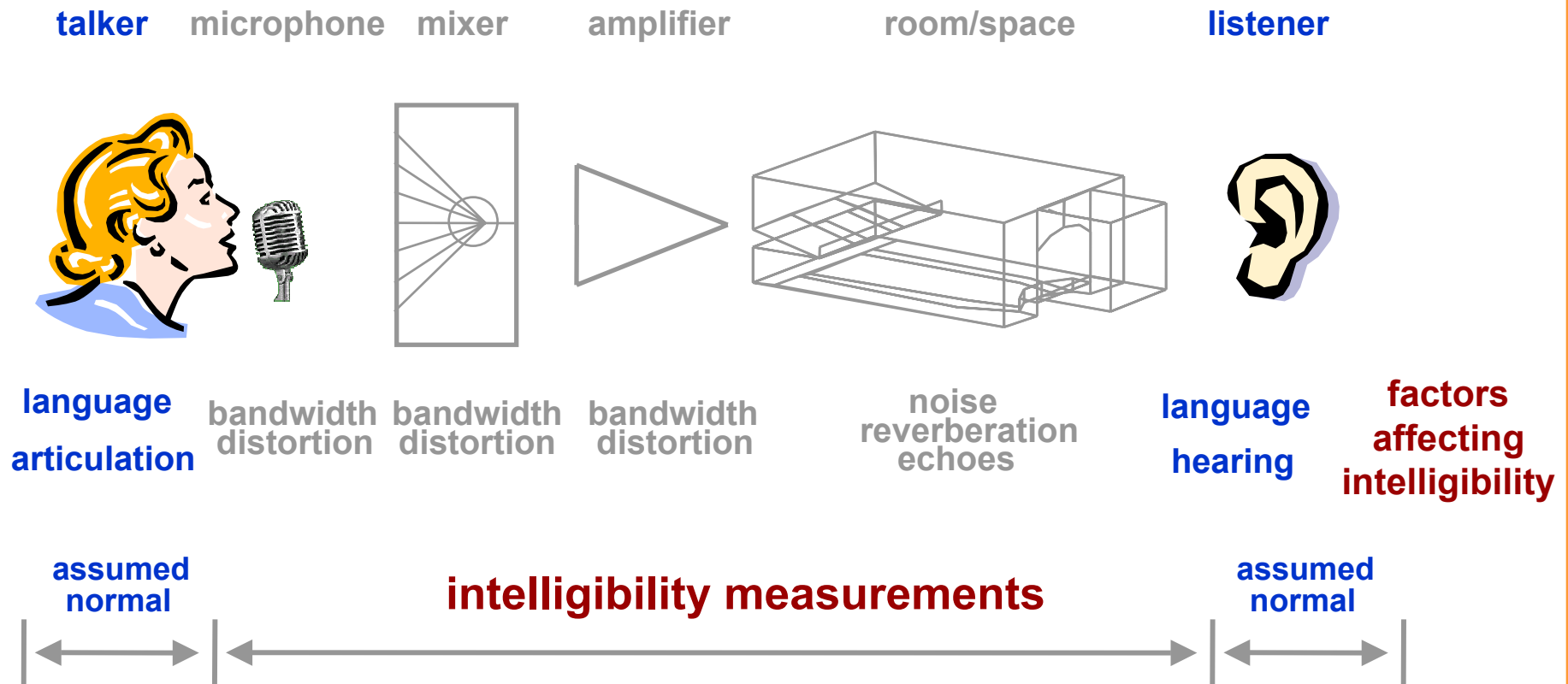
Code requirement: NFPA 72 [2002] – Chapter 7

- **7.4.1.4*** Where required, emergency voice/alarm communications systems shall be capable of the reproduction of prerecorded, synthesized, or live (e.g., microphone, telephone handset, and radio) messages **with voice intelligibility.**

NFPA 72 [2002] *con't*

- **A.7.4.1.4** Voice intelligibility should be measured in accordance with the guidelines in Annex A of IEC 60849, Second Edition: 1998, Sound systems for emergency purposes. When tested in accordance with Annex B, Clause B1, of IEC 60849, the system should exceed the equivalent of a **common intelligibility scale (CIS) score of 0.70**. Intelligibility is achieved when the quantity $I_{av}-\sigma$, as specified in B3 of IEC 60849, exceeds this value. I_{av} is the arithmetical average of the measured intelligibility values on the CIS and σ (sigma) is the standard deviation of the results.

Variables that Determine Intelligibility



When to Consider Computer Modeling

- Large auditoria, arenas, convention centers
- Transportation facilities (e.g., airports, train stations)
- Spaces with very high ceilings
- Spaces with lots of hard surfaces (marble, plaster, glass)
- Spaces with high ambient noise



Common Intelligibility Problems

<u>Problem</u>	<u>Potential Solution</u>
Low signal to noise level	■ Increase system signal power ■ Adjust speaker power ■ Add speakers in enclosed spaces ■ Adjust output based upon variable ambient noise level
High reverberation	■ Add sound absorbing materials to space ■ Move speakers closer to occupants ■ Reduce speaker volume

Reference Information

- <http://www.noisenet.org/index.htm>
- <http://www.mcsquared.com>
- <http://www.meyersound.com>
- <http://www.hnd.usace.army.mil/techinfo/UFC/UFC4-021-01.pdf>
- <http://www.gold-line.com>

Reference Information

■ NFPA 72 [2002] Handbook

- ⌘ Supplement 5 – Voice Intelligibility for Emergency Voice/Alarm Communications – R.P. Schifiliti
- ⌘ Supplement 2 – Interfacing Fire Alarm Systems and Elevator Controls – R.B. Fraser
- ⌘ Chapter 7 – 7.3.2.3 Guidance on determining voltage drop calculations